UNIVERSITI SAINS MALAYSIA

Second Semester Examination
Academic Session 2005/2006

April/May 2006

IEK 203E – Water Treatment Plant Design
[Rekabentuk Peralatan Pengolahan Air]

Duration: 3 hours
[Masa: 3 jam]

Please check that this examination paper consists of THIRTEEN pages of printed material before you begin the examination.

Answer FIVE questions. Questions can be answered in Bahasa Malaysia OR English.

[Sila pastikan bahawa kertas peperiksaan ini mengandungi TIGA BELAS mukasurat yang bercetak sebelum anda memulakan peperiksaan ini.]

[Jawab LIMA soalan. Soalan boleh dijawab dalam Bahasa Malaysia ATAU Bahasa Inggeris.]

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1. Make a preliminary estimate of the approximate pipe size required for the following services:

   (a) A transcontinental pipeline to carry 250,000 standard m^3/h of natural gas at 20 atmosphere absolute and 20°C;

   (b) Feeding a slurry of in water to a continuous centrifugal separator at the rate of 1 ton /h of solids. The slurry carries 45 percent solids by weight. Given that the density of slurry is 1475 kg/m^3.

(100 marks)

2. Benzene at 100°F (37.8°C) is pumped through the system of Figure 1 at the rate of 40 gal/min (9.09 m^3/h). The reservoir is at atmospheric pressure. The gauge pressure at the end of the discharge line is 50 lb_f/in^2(345kN/m^2). The discharge is 10 feet and the pump suction is 4 feet above the level in the reservoir. The discharge line is 1 ½ in (1.5 in) schedule 40 pipe. The friction in the suction line is known to be 0.5 lb_f/in^2(3.45kN/m^2), and its vapor pressure at 100°F (37.8°C) is 3.8 lb_f/in^2 (26.2 kN/m^2). Calculate If the pump manufacturer specifies a Net Positive Suction Head Requirement (NPSHR) of 10 ft (3.05), will the pump be suitable for this service.

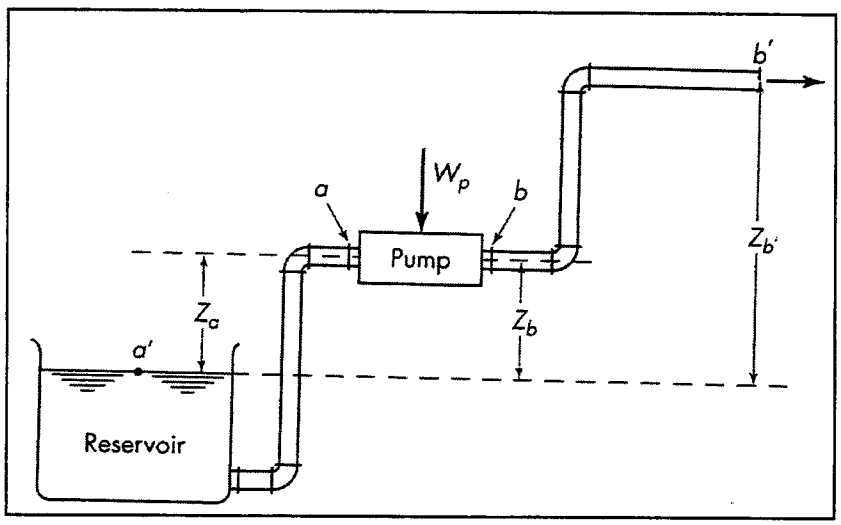


Figure. 1 Pump flow system

(100 marks)

3. Describe the physical properties and purpose of a simple gravity settling tank. How can you modify it into a sedimentation thickener? Show a complete diagram of a continuous thickener of a primary sludge removal tank in a water treatment plant.

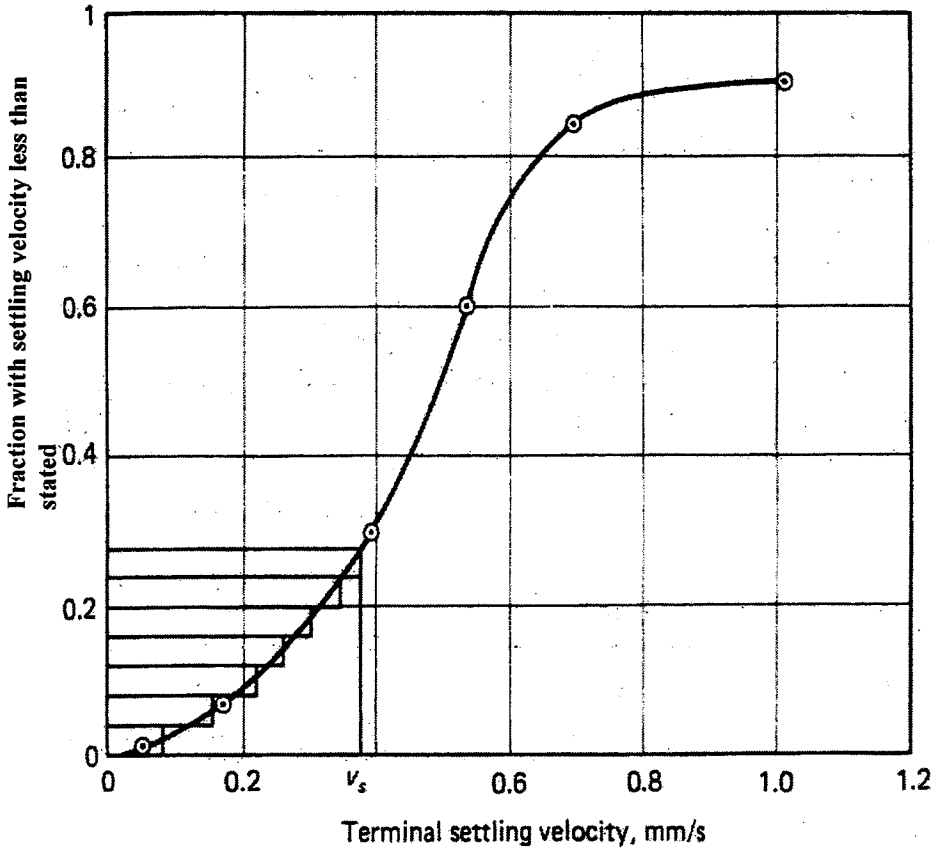
(100 marks)

4. A rotary drum filter with 30 percent submergence is to be used to filter concentrated aqueous slurry of $CaCO_3$ containing 14.7 lb of solid per cubic foot of water (236 kg/m^3). The pressure drop is to be 20 in. Hg. If the filter cake contains 50 percent moisture (wet basis), calculate the filter area required to filter 10 gal/min of slurry when the filter cycle time is 5 min. Assume that the specific cake resistance and that the filter medium resistance R_m is negligible. The temperature is 20°C.

(100 marks)

5. A settling basin is designed to have a surface overflow rate of 32.6 m/day [800 gal/(ft^2·d)]. Determine the overall removal obtained for a suspension with the size distribution given in the table below. The specific gravity of the particles is 1.2 and the water temperature is 20°C.

Particle size, mm	**0.10**	**0.08**	**0.07**	**0.06**	**0.04**	**0.02**	**0.01**
Weight fraction greater than size, %	10	15	40	70	93	99	100



Terminal settling velocity, mm/s
Overall removal settling Characteristics of Suspension

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6. From the settling curves of Figure 2, determine the theoretical efficiency of a sedimentation tank with a depth equal to the test cylinder and a detention time of 25min. What surface overflow rate should be used in a full-sized clarifier in order to achieve equivalent results? The test cylinder has a depth of 3m (9.8ft).

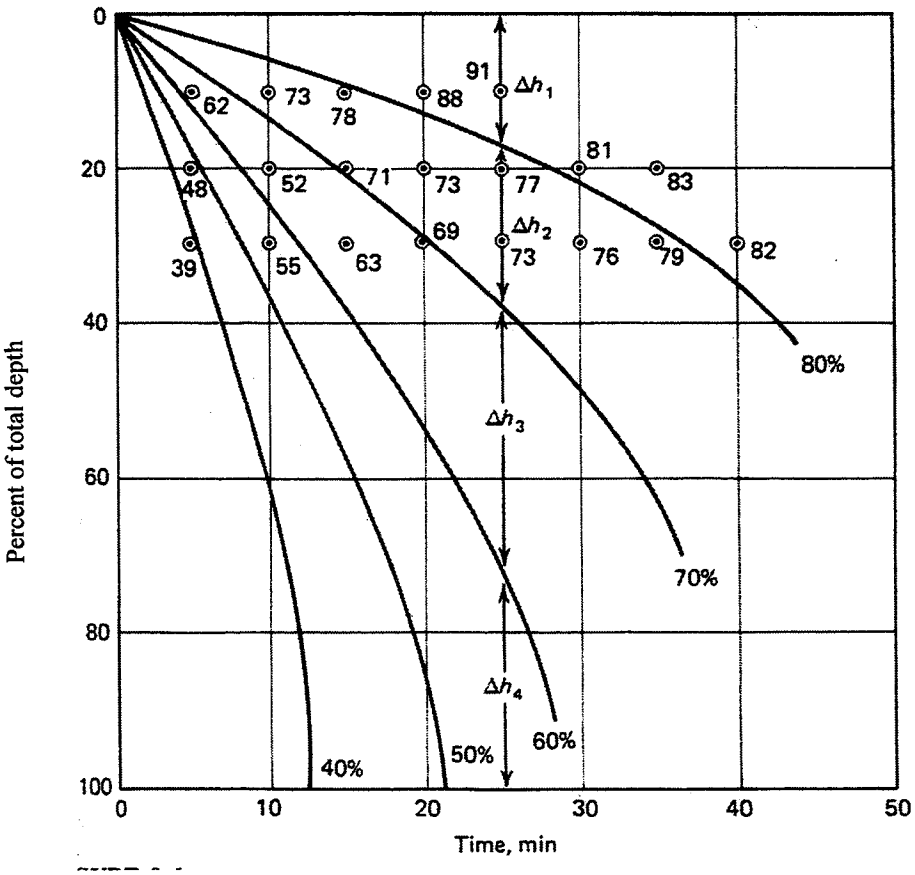

Figure 2 Settling of a flocculent suspension

(100 marks)

7. A membrane process is being designed to recover solute A from a dilute solution where c_1 = 2.0 X 10^{-2} kg mol A/m^3 by dialysis through a membrane to a solution where c_2 = 0.3 X 10^{-2} kg mol. The membrane thickness is 1.59 X 10^{-5} m, the distribution coefficient K = 0.75, D_{AB} = 3.5 X 10^{-11} m^2/s in the membrane, the mass-transfer coefficient in the dilute solution is k_{c1} = 3.5 X 10^{-5} m/s, and k_{c2} =2.1 X 10^{-5}.

   (a) Calculate the individual resistance, total resistance, and total percent resistance of the two films.

   (b) Calculate the flux at steady state and the total area in m^2 for a transfer of 0.01 kg mol solute/h.

   (c) Increasing the velocity of both liquid phases flowing past surface of the membrane will increase the mass-transfer coefficients, which are approximately proportional to $v^{0.6}$, where v is velocity. If the velocities are doubled, calculate the total percent resistance of the two films and the percent increase in flux.

(100 marks)

APPENDIX 3

PHYSICAL PROPERTIES OF WATER

Physical properties of water at different temperatures

Temperature, °C	Density, g/cm³	Absolute viscosity, cP	Kinematic viscosity, cSt	Vapor pressure, kPa
0	0.99987	1.7921	1.7923	0.61
2	0.99997	1.6740	1.6741	0.71
4	1.00000	1.5676	1.5676	0.82
6	0.99997	1.4726	1.4726	0.94
8	0.99988	1.3872	1.3874	1.09
10	0.99973	1.3097	1.3101	1.23
12	0.99952	1.2390	1.2396	1.42
14	0.99927	1.1748	1.1756	1.61
16	0.99897	1.1156	1.1168	1.81
18	0.99862	1.0603	1.0618	2.02
20	0.99823	1.0087	1.0105	2.33
22	0.99780	0.9608	0.9629	2.66
24	0.99733	0.9161	0.9186	3.02
26	0.99681	0.8746	0.8774	3.38
28	0.99626	0.8363	0.8394	3.71
30	0.99568	0.8004	0.8039	4.24

$g/cm^3 \times 62.42 = lb/ft^3$

Centipoise $\times 2.088 \times 10^{-5} = lbf \cdot s/ft^2$

Centistoke $\times 1.075 \times 10^{-5} = ft^2/s$

Kilopascal $\times 0.145 = lb/in^2$

1. *Nyatakan berapakah anggaran saiz paip yang diperlukan bagi tujuan berikut:*

   (a) Sesalur paip yang membawa 250,000 m^3/jam pada piawai dari gas asli pada 20 atmosfera tentu dan 20°C merentasi benua;

   (b) Sebatian yang mengandungi pepejal terampai di dalam air dialirkan ke pemisah sentrifugal berterusan pada kadar 1 ton/jam pepejal. Sebatian tersebut mengandungi pepejal seberat 45 peratus.

   Diberi bahawa ketumpatan sebatian adalah 1475 kg/m^3.

   (100 markah)

2. *Air pada suhu 100°F (37.8°C) dipam melalui sistem yang ditunjukkan dalam gambarajah 1.0 pada kadar 40 gal/min (9.09 m^3/jam). Empangan berada pada tekanan atmosfera. Tekanan gauge yang dianggarkan bagi titik discas adalah 50 lb_f/in^2 (345kN/m^2). Discas tersebut berada pada 10 kaki dan kedudukan pam ialah 4 kaki daripada paras empangan. Saluran paip adalah 1 ½ in. (1.5 in) Jadual 40. Geseran dalam saluran penyedutan yang diketahui iaitu 0.5 lb_f/in^2(3.45kN/m^2), tekanan wap pada 100°F (37.8°C) ialah 3.8 lb_f/in^2 (26.2 kN/m^2). Jika pembekal pam menyatakan Net Positive Suction Head Requirement (NPSHR) sebanyak 10 kaki (3.05), kirakan sama ada pam tersebut sesuai untuk digunakan.*

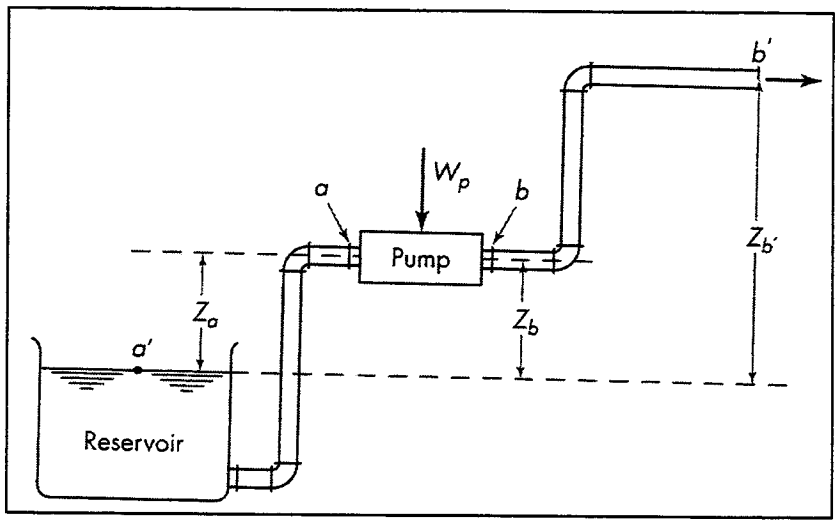

Fig. 1 Pump flow system

(100 markah)

3. *Jelaskan ciri-ciri fizikal dan tujuan suatu tangki pemendakan graviti yang asas. Bagaimanakah anda dapat mengubahsuaikannya kepada pemekatan sedimen? Tunjukkan gambarajah bagi "continuous thickener" suatu tangki pengeluaran enapcemar di loji rawatan air.*

(100 markah)

4. *Sebuah tong berpenapis berputar tenggelam sebanyak 30 peratus digunakan untuk menapis slurry akues pekat $CaCO_3$ yang mengandungi 14.7 lb bahan pepejal pada setiap kaki per segi air (236 kg/m^3). Penurunan tekanan adalah 20 in.Hg. Jika penapis kek mengandungi kelembapan 50 peratus (dasar lembap), kirakan luas penapis yang diperlukan untuk menapis 10 gal/min slurry apabila masa kitaran penapisan adalah 5 minit. Anggap bahawa rintangan kek spesifik dan rintangan media penapis R_m boleh diabaikan. Suhu adalah 20°C.*

(100 markah)

5. *Suatu tangki pemendapan direka supaya mempunyai kadar permukaan limpah sebanyak 32.6 m/day [800 gal/ (ft^2 d)]. Tentukan jumlah penyingkiran untuk ampaian dengan saiz penyerakan yang diberi dalam jadual di bawah. Graviti spesifik partikel ialah 1.2 manakala suhu air ialah 20°C.*

Saiz partikel, mm	*0.10*	*0.08*	*0.07*	*0.06*	*0.04*	*0.02*	*0.01*
Pecahan Jisim lebih besar daripada Saiz, %	*10*	*15*	*40*	*70*	*93*	*99*	*100*

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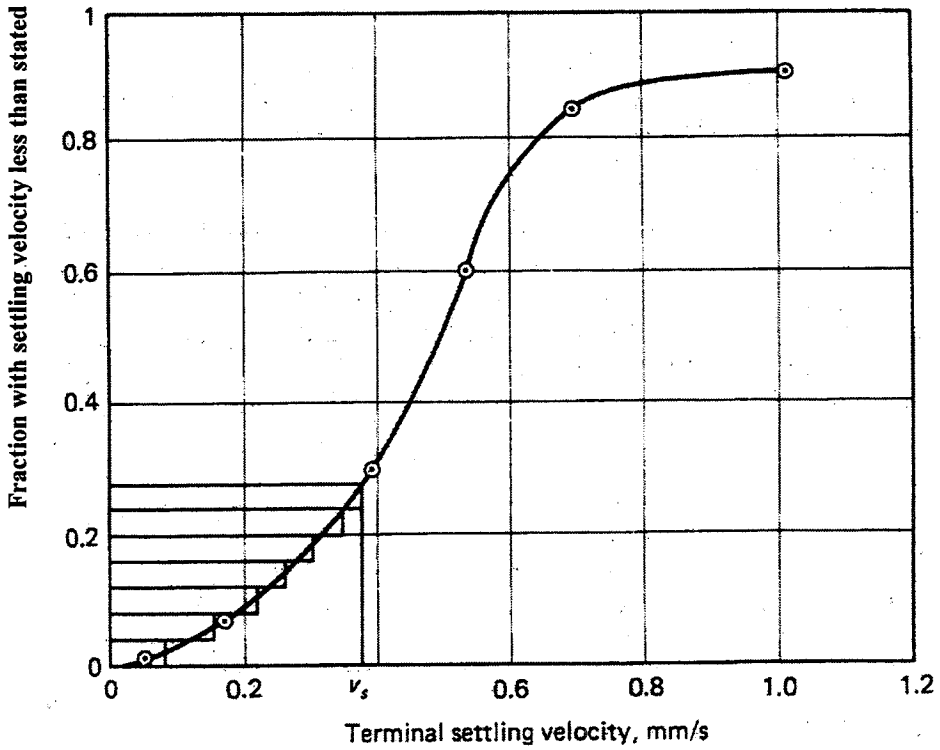

Terminal settling velocity, mm/s
Overall removal settling Characteristics of Suspension

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6. *Merujuk kepada lengkuk pemendapan yang diberi di bawah, tentukan keefisienan tangki pemendapan yang mempunyai kedalaman yang sama dengan silinder ujian serta masa tahanan selama 25 minit. Apakah kadar permukaan limpah yang patut digunakan dalam sebuah klarifier bersaiz penuh supaya mencapai keputusan yang sama. (selinder ujian mempunyai kedalaman 3m (9.8ft)).*

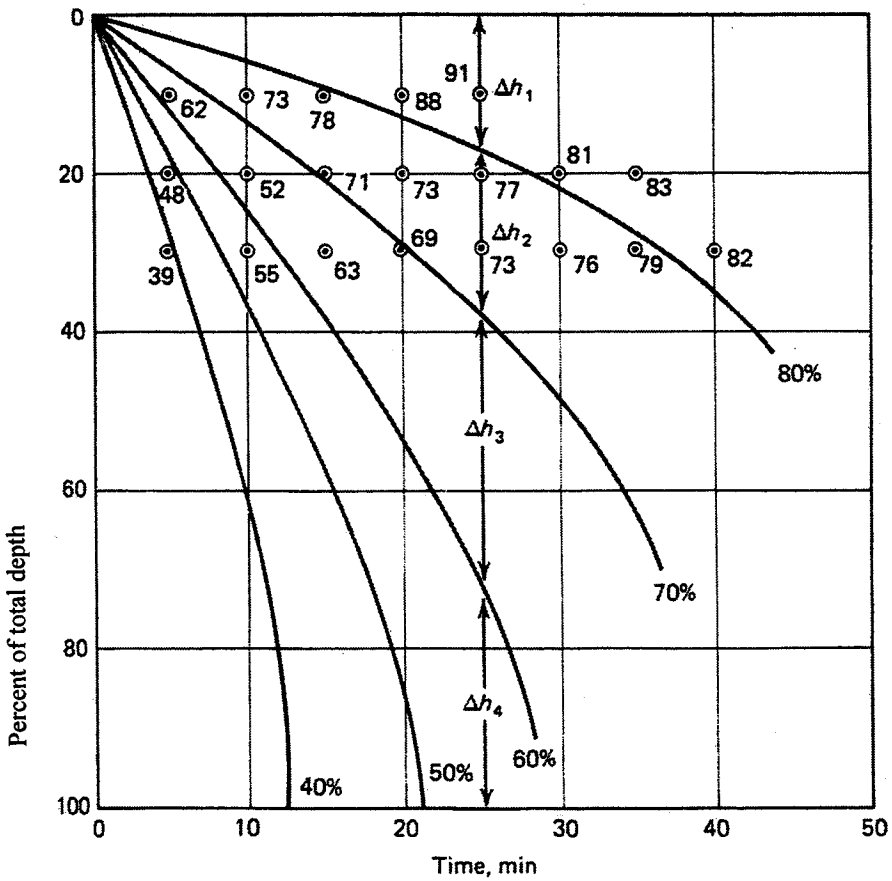

Figure 2 Settling of a flocculent suspension

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7. *Serakan melalui bendalir dan membran. Suatu proses membran direka untuk mengembalikan bahan A daripada larutan cair di mana* $c_1 = 2.0 \times 10^{-2}$ *kg mol A/m*^{3} *secara dialisis melalui membran kesatu larutan di mana* $c_2 = 0.3 \times 10^{-2}$ *kg mol. Ketebalan membran adalah* 1.59×10^{-5} *m, koefisien penyerakan* $K' = 0.75$, $D_{AB} = 3.5 \times 10^{-11}$ *m*^{2}*/s di dalam membran, koefisien pemindahan jisim dalam larutan cair adalah* $k_{c1} = 3.5 \times 10^{-5}$ *m/s, and* $k_{c2} = 2.1 \times 10^{-5}$.

   (a) Kirakan rintangan individu, rintangan keseluruhan dan peratusan rintangan keseluruhan kedua filem.

   (b) Kirakan fluks pada keadaan mantap dan jumlah keluasan dalam unit m^2 *untuk pemindahan 0.01kg mol cecair/jam.*

   (c) Apabila halaju kedua-dua fasa cecair yang mengalir melalui permukaan membran ditingkatkan, koefisien pemindahan jisim akan meningkat kira-kira $v^{0.6}$, *dimana v adalah halaju. Jika halaju digandakan, kirakan peratusan jumlah rintangan kedua-dua filem dan peratus peningkatan dalam fluks.*

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